

Before the
Federal Communications Commission
Washington, D.C. 20554

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FCC 08-260

In the Matter of)	
)	
Unlicensed Operation in the TV Broadcast Bands)	ET Docket No. 04-186
)	
Additional Spectrum for Unlicensed Devices)	ET Docket No. 02-380
Below 900 MHz and in the 3 GHz Band)	

SECOND REPORT AND ORDER AND MEMORANDUM OPINION AND ORDER

Adopted: November 4, 2008

Released: November 14, 2008

By the Commission: Chairman Martin, and Commissioners Copps, Adelstein, and McDowell issuing separate statements; Commissioner Tate approving in part, dissenting in part and issuing a statement.

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I. EXECUTIVE SUMMARY

1. In this Second Report and Order, we adopt rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used by licensed services (this unused TV spectrum is often termed "white spaces"). This action will make a significant amount of spectrum available for new and innovative products and services, including broadband data and other services for businesses and consumers. The actions we take here are a conservative first step that includes many safeguards to prevent harmful interference to incumbent communications services. Moreover, the Commission will closely oversee the development and introduction of these devices to the market and will take whatever actions may be necessary to avoid, and if necessary correct, any interference that may occur. Further, we will consider in the future any changes to the rules that may be appropriate to provide greater flexibility for development of this technology and better protect against harmful interference to incumbent communications services. Briefly, the rules we are adopting provide for the following capabilities and safeguards:

- We are providing for both fixed and personal/portable devices to operate in the TV white spaces on an unlicensed basis.
- All devices, except personal/portable devices operating in client mode, must include a geolocation capability and provisions to access over the Internet a database of protected radio services and the locations and channels that may be used by the unlicensed devices at each location. The unlicensed devices must first access the database to obtain a list of the permitted channels before operating.
- The database will be established and administered by a third party, or parties, to be selected through a public notice process to solicit interested parties.
- Fixed devices may operate on any channel between 2 and 51, except channels 3, 4 and 37, and subject to a number of other conditions such as a restriction against co-channel operation or operation adjacent TV channels pending consideration of further information that may be submitted into the record in this proceeding. Fixed devices may operate at up to 4 Watts EIRP (effective isotropic radiated power).
- Personal portable devices may operate on any unoccupied channel between 21 and 51, except channel 37. Personal portable devices may operate at up to 100 milliwatts of power, except that operation on adjacent channels will be limited to 40 milliwatts.
- Fixed and personal/portable devices must also have a capability to sense TV broadcasting and wireless microphone signals as a further means to minimize potential interference. However, for TV broadcasting the database will be the controlling mechanism.
- Wireless microphones will be protected in a variety of ways. The locations where wireless microphones are used, such as entertainment venues and for sporting events, can be registered in the database and will be protected as for other services. In addition, channels from 2 – 20 will be restricted to fixed devices, and we anticipate that many of these channels will remain available for wireless microphones that operate on an itinerant basis. In addition, in 13 major markets where certain channels between 14 and 20 are used for land mobile operations, we will leave 2 channels between 21 and 51 free of new unlicensed devices and therefore available for wireless microphones. Finally, as noted above, we have required that devices

also include the ability to listen to the airwaves to sense wireless microphones as an additional measure of protection for these devices.

- Devices must adhere to certain rules to further mitigate the potential interference and to help remedy potential interference should it occur. For example, all fixed devices must register their locations in the database. In addition, fixed devices must transmit identifying information to make it easier to identify them if they are found to interfere. Furthermore, fixed and personal/portable devices operating independently must provide identifying information to the TV bands database. All devices must include adaptable power control so that they use the minimum power necessary to accomplish communications.
- All white space devices are subject to equipment certification by the FCC Laboratory. The Laboratory will request samples of the devices for testing to ensure that they meet all the pertinent requirements.
- We will permit applications for certification of devices that do not include the geolocation and database access capabilities, and instead rely on spectrum sensing to avoid causing harmful interference, subject to a much more rigorous set of tests by our Laboratory in a process that will be open to the public. These tests will include both laboratory and field tests to fully ensure that such devices meet a "Proof of Performance" standard that they will not cause harmful interference. Under this procedure the Commission will issue a Public Notice seeking comment on the application, as well as test procedures and methodologies. The Commission will also issue a Public Notice seeking comment on its recommendations. The decision to grant such an application will then be made at the Commission level.
- The Commission will act promptly to remove any equipment found to be causing harmful interference from the market and will require the responsible parties to take appropriate actions to remedy any interference that may occur.

II. INTRODUCTION

2. In this Second Report and Order, we adopt rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used by licensed services (this unused TV spectrum is often termed "white spaces"). This action will open for use a significant amount of spectrum with very desirable propagation characteristics that has heretofore lain fallow. These new rules will allow the development of new and innovative types of unlicensed devices that provide broadband data and other services for businesses and consumers without disrupting the incumbent television and other authorized services that operate in the TV bands. In addition, because transmissions on frequencies in the TV bands are less subject to propagation losses than transmissions in the spectrum bands where existing low power broadband unlicensed operations are permitted, *i.e.*, the 2.4 GHz and 5 GHz bands, we anticipate that allowing unlicensed operation in the TV bands will benefit wireless internet service providers (WISPs) by extending the service range of their operations. This will allow wireless broadband providers that use unlicensed devices to reach new customers and to extend and improve their services in rural areas. We anticipate that allowing use of the TV white spaces by unlicensed devices will have significant benefits for both businesses and consumers and thereby promote more efficient and effective use of the TV spectrum.

3. The plan we are adopting will allow both fixed and personal/portable unlicensed devices to operate on unused television channels in locations where such operations will not result in harmful interference to TV services (including reception by cable headends and low power TV stations, *i.e.*, TV translator, low power TV, TV booster, and Class A TV stations) and other services that use the TV

bands.¹ We recognize the importance of protecting licensed services from harmful interference and the novel challenges involved in reliably identifying unused TV channels. We therefore are taking a cautious and conservative approach in this plan, balancing the need to provide sufficient opportunities for proponents to develop viable unlicensed TV band devices (TVBDs) with measures to ensure that such devices fully protect the important licensed services that operate in the TV bands. In allowing the introduction of unlicensed TVBDs, we also believe it is important to avoid the possibility of disrupting or causing uncertainty in the DTV transition, the current ongoing process whereby TV stations are changing from analog to digital (DTV) operation. As set forth in the *First Report and Order and Further Notice of Proposed Rulemaking (First R&O/Further Notice)* in this proceeding, we have addressed this concern with regard to the DTV transition by restricting the marketing of unlicensed TVBDs until February 18, 2009, the date when the DTV transition will end and all full-power TV stations will be operating on a single channel, and only with digital signals.²

4. We anticipate that the capabilities of products for operating in this spectrum will develop and evolve over time and that much will be learned about the potential for unlicensed TVBDs to cause interference to licensed services and how to avoid that interference. We may therefore need to revisit these rules to make adjustments both to provide more flexibility for unlicensed devices and to refine the protections for licensed services. Consistent with our objective to allow unlicensed TVBDs to operate with the most flexibility and capabilities possible consistent with protection of licensed services, we are directing our staff to conduct a review and report to the Commission in two years from the date of this Second Report and Order on the state of these devices, including the types of devices on the market, the extent of their implementation, technical developments, any interference problems that may have arisen, and aspects of the rules that should be altered to increase features and opportunities for use or to address conflicts.

5. We are also denying all aspects of a petition for reconsideration submitted by the New America Foundation and the Champaign Urbana Wireless Network (NAF/CUWN).³ In particular, we are denying their request that we 1) not re-open the issue of whether to permit new uses of the TV bands on a licensed or unlicensed basis; 2) allow personal/portable devices on channels 14-20; and 3) allow marketing of new unlicensed TV band devices prior to the end of the DTV transition.

6. *Overview of Rules for Unlicensed TV Band Devices.* The new rules provide for operation of two types of unlicensed TVBDs that may provide broadband data and other types of communications services: 1) fixed devices, which will operate from a fixed location with relatively higher power and could be used to provide a variety of services including wireless broadband access in urban and rural areas, and 2) personal/portable devices, which will use lower power and could, for example, take the form

¹ As discussed below, the TV spectrum is also used on a licensed basis by wireless microphone, private land mobile radio, commercial mobile radio, broadcast auxiliary, off-shore radio, and radio astronomy operations. TV translators are low power TV stations that receive a signal from a full service TV station on one channel and retransmit that signal on a different channel in an area where the full service TV station is not normally received. Low power TV stations operate similar to TV translators and may retransmit the signals of a full service TV station and also originate programming. TV booster stations also operate similar to TV translators but transmit on the same channel as their full service station and within the service area of that full service station. Class A stations operate under technical rules similar to low power TV and TV translator stations but are subject to certain minimum operating requirements for service hours and locally originated programming.

² See *First Report and Order and Further Notice of Proposed Rule Making* in ET Docket Nos. 02-380 and 04-186, 21 FCC Rcd 12266 (2006).

³ See Petition for Reconsideration of the *First R&O/Further Notice* submitted by the NAF and the Champaign Urbana Wireless Network, December 18, 2006.

of devices such as Wi-Fi-like cards in laptop computers or wireless in-home local area networks (LANs). In order to operate without causing interference to licensed services, both types of devices will be required to be able to reliably determine which channels are occupied by licensed operations at their location at any given time and to avoid interfering with services on those channels using the following methods. Devices will be required to identify unused channels as follows:

- a) A fixed device must employ both geo-location/database access and spectrum sensing capabilities that enable the device to listen for and identify the presence of signals from other transmitters;
- b) A personal/portable device must either 1) be under the control of a fixed device or a personal/portable device that employs geolocation/database access and spectrum sensing or 2) employ geo-location/database access and spectrum sensing itself.

7. In addition, we are adopting rules that will allow for certification of personal/portable devices that do not include geo-location and database access capabilities and are not controlled by another device but rather determine available channels using spectrum sensing, perhaps in combination with some other techniques. These devices will be required to meet a "proof of performance" standard that they will not cause harmful interference to incumbent radio services. Such devices will be subject to all of the other requirements for personal/portable devices but would be limited to 50 milliwatts (mW) EIRP rather than the 100 mW authorized for personal/portable devices for which available channels are determined based on the geolocation and database method. The certification process will require submittal of a sample for testing in our laboratory and in the field similar to the process that the FCC Laboratory followed for testing of TV band devices. The sample device must be a fully functioning pre-production prototype, identical to the device that will be marketed except for cosmetics. The testing will be open to the public. The application must also show how the device will protect the various incumbent radio services discussed herein. The determination of whether to certify the device will be based on a demonstrated ability to avoid causing harmful interference with an extremely high degree of reliability. If the device is certificated, we will permit routine certification of other devices that have identical characteristics (i.e., have the identical electrical characteristics and antenna system.). We will endeavor to complete the certification process within 180 days of submittal of the device for testing, barring any unforeseen circumstances.

8. *Fixed Devices.* Fixed devices will be allowed to communicate with other fixed devices and with personal portable devices. These devices will be required to determine their geographic location through an incorporated geo-location capability or from a professional installer and to access and register with a database system that contains records of protected services and receive back either a list of the available channels at their location or information on the channels used in their area from which they can determine a list of available channels. In addition, fixed devices will be required to operate with antennas mounted outdoors and to use spectrum sensing to identify any wireless microphone operations and any other protected signals that might be present at their location but do not appear in the database. These devices will be required to sense, at levels as low as -114 dBm, TV signals (digital and analog), wireless microphone signals, and signals of other services that operate in the TV bands on intermittent basis. Fixed devices will be allowed to operate at up to 1 watt (W) transmitter output power and with a gain antenna to achieve 4 W equivalent isotropically radiated power (EIRP), and to communicate with other fixed devices and personal/portable devices, except that they may not communicate with personal/portable devices when operating on channels in the range 2-20. This plan for fixed devices is similar to the provisions of the draft standard for TVBDs under consideration by IEEE 802.22.⁴

⁴ See IEEE 802.22/D0.2 "Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in (continued....)"

9. *Personal/portable Devices.* Personal/portable devices will be allowed to communicate with fixed devices and with other personal/portable devices. These devices will be allowed to operate in two different modes: 1) Mode I - client, whereby a personal/portable device is controlled by a fixed or a personal/portable device operating in Mode II that has determined the available channels in the area and/or 2) Mode II - independent, whereby a personal/portable device determines the available channels using its own internal geo-location/database access capabilities. Personal/portable operations will be permitted at up to 100 mW EIRP, with no antenna gain, except that when operating on a channel adjacent to a TV station or other licensed station/service and within the protected coverage area of that service, operations will be limited to 40 milliwatts. A device operating in Mode II using its own internal geo-location and database access capabilities will be allowed to communicate with other personal/portable devices and function as the master device in a master/client link with another personal/portable device. Devices operating in either mode will be required to sense TV signals, wireless microphone signals, and signals of other services that operate in the TV bands, including those that operate on intermittent basis, at levels as low as -114 dBm. Personal portable devices will not be required to register with the database system.

10. *All Devices.* All unlicensed TV band fixed and personal/portable TV band devices will be permitted to operate on TV channels 21-51, excluding channel 37. In addition, fixed TVBDs that only communicate with other fixed TVBDs will be permitted to operate on channels 2 and 5-20, except that they must avoid operation on channels used by private land mobile radio service (PLMRS), *i.e.*, public safety, and commercial mobile radio service operations on channels in certain markets and areas adjacent to them. Also, in individual markets where there are Private Land Mobile Radio Service or Commercial Mobile Radio Service (PLMRS/CMRS) operations on channels 14-20, two channels in the range 21-51 will be reserved for operation by wireless microphones such that TVBDs will not be permitted on those channels. This plan for channel use is consistent with the requests of the various white space proponents and would reserve channels for a "safe harbor" for operation of wireless microphones and ensure protection of the public safety and other land mobile services that use channels 14-20. At this time, we are only permitting fixed TVBDs to operate on channels not that are not immediately next to (first adjacent on either side of) the channel of a TV station; personal portable devices will be allowed to operate on first adjacent channels to a TV station subject to the power limitation indicated above. All unlicensed TV band devices will be required to limit their out-of-band emissions in the first adjacent channel to a level 55 dB below the power level in the channel they occupy, as measured in a 100 kHz bandwidth. In addition, all TVBDs will be required to comply with a more stringent out-of-band emissions band at the edges of channels 36 and 38 that are adjacent to channel 37 in order to protect medical telemetry devices on that channel 37. Fixed devices will also be required to periodically transmit a signal with their identification when they are operating. This will facilitate identification of sources of interference. The database system for fixed stations and personal/portable devices with geo-location and database access capability will be managed by a database manager or managers selected by our Office of Engineering and Technology. The specific provisions of this plan are presented below.

III. BACKGROUND

11. The Commission provides for the operation of unlicensed radio transmitters in Part 15 of its rules.⁵ Under these rules, unlicensed devices generally operate on frequencies shared with authorized

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the TV Bands," prepared by the IEEE 802.22 Working Group of the LAN/MAN Standards Committee, November 2006. We note, however, that the IEEE 802.22 plan does not provide for fixed devices to communicate with personal/portable devices on a master/client basis.

⁵ See 47 C.F.R. Part 15.

services and at relatively low power, *i.e.*, at power levels 1 W or less. Operation under Part 15 is subject to the condition that a device does not cause harmful interference to authorized services, and that it must accept any interference received.⁶ The current Part 15 rules provide substantial flexibility in the types of unlicensed devices that can be operated, but prohibit the operation of unlicensed devices on certain frequencies, including the bands used for broadcast television service.⁷

12. The broadcast television service operates under Part 73 of the rules. TV stations operate on six-megahertz channels designated channels 2 to 69 in four bands of frequencies in the VHF and UHF regions of the radio spectrum (54-72 MHz, 76-88 MHz, 174-216 MHz and 470-806 MHz).⁸ As noted above, television stations are now in the process of converting from analog to digital transmissions.⁹ During the transition to digital transmissions, each full service television station that was authorized before 1997 is required to broadcast on two channels, one digital and one analog.¹⁰ At the end of the transition on February 17, 2009, each full service TV station must cease analog operation and operate on a single digital channel.¹¹ Because the new digital TV transmission system is more spectrally efficient than the analog TV transmission system, the Commission has relaxed some of the current analog TV channel separation requirements for digital operation and has eliminated others. Consequently, it has been able to accommodate all existing television stations with channels for post-transition operation in less spectrum. The Commission has specified that digital television stations will operate only on channels 2-51 after the transition and has reallocated television channels 52-69 for other uses.¹²

13. To avoid interference between TV stations, stations on the same and adjacent channels (and in the case of analog TV service certain other channel relationships) must comply with minimum

⁶ See 47 C.F.R. § 15.5.

⁷ See 47 C.F.R. §§ 15.205 and 15.209. Section 15.205 sets forth the restricted bands for operation where unlicensed intentional radiators are not allowed to operate. Section 15.209 provides the general radiated emission limits that apply to intentional radiators, including limits on their out-of-band emissions. Remote control and medical telemetry devices are the only unlicensed transmitters that are currently permitted to operate in the TV bands. See 47 C.F.R. §§ 15.231, 15.241 and 15.242.

⁸ See 47 C.F.R. § 73.603(a). After February 17, 2009, only low power television stations will be permitted to operate on channels 52-69.

⁹ See for example, *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket 87-268, *Sixth Report and Order*, 12 FCC Rcd 14588 (1997).

¹⁰ The analog and digital TV channels currently used by full service TV stations are set forth in Sections 73.606 and 73.622 of the rules, respectively, see 47 C.F.R. §§ 73.606 and 73.622. In developing the initial Table of Allotments for stations' digital TV operations, the channels were selected to minimize or prevent interference between digital stations and between analog and digital stations. Requests for modification of stations on channels in the initial (1998) DTV Table of Allotments are evaluated for technical acceptability using minimum desired-to-undesired (D/U) signal ratios, see 47 C.F.R. § 73.623(c). New digital allotments added after the initial digital TV Table of Allotments must meet minimum separation distances to both digital and analog TV stations, see 47 C.F.R. § 73.623(d). The Commission has issued a *Report and Order* in the third DTV periodic review in which it, *inter alia*, modified the technical standards for new stations and modifications of digital and analog stations to prepare for stations' final conversion to all digital operation, see *Report and Order* in MB Docket No. 07-91, 23 FCC Rcd 2994 (2007).

¹¹ See Title III of the Deficit Reduction Act of 2005, Pub. L. 109-171, 120 Stat. 4, 21 (Feb. 8, 2006).

¹² See *Sixth Report and Order* in MM Docket No. 87-268, *supra*; see also, *First Report and Order* in WT Docket No. 99-168, 15 FCC Rcd 476 (2000), *Report and Order* in ET Docket No. 97-157, 12 FCC Rcd 22953 (1998) and *Report and Order* in GN Docket No. 01-74, 17 FCC Rcd 1022 (2002).

separation distance requirements and other technical provisions.¹³ As a result of these provisions, there are geographic areas between the stations on any given channel in local areas where TV service is not available. There are typically a number of TV channels in a given geographic area that are not being used by full service digital TV stations because such stations would not be able to operate without causing interference to co-channel or adjacent channel stations. The minimum separation distances (spacings) between stations are based on the assumption that the stations will operate at the maximum permitted antenna height and power.¹⁴ However, a transmitter operating on a vacant TV channel, *e.g.*, a channel not used by a high power TV station in a given geographic area due to interference concerns, at a lower antenna height and/or power level than a TV station operating at the maximum allowed facilities would not need as great a separation distance from co-channel and adjacent channel TV stations to avoid causing interference to such stations. Also, in some areas channels that could be used by a full service television station simply are not being used. This situation will remain after the transition.

14. In addition to full service TV stations operating under Part 73 of the rules, certain other licensed services are permitted to operate on TV channels. Class A television stations operate under Subpart J of Part 73 of the rules.¹⁵ Low power TV, TV translator and TV booster stations are permitted to operate under Part 74 of the rules on a secondary basis to full service TV stations and on an equal basis with Class A TV stations, provided they meet technical rules to prevent interference to reception of such stations.¹⁶ Part 74 also permits certain broadcast auxiliary operations on TV channels 14-69 on a secondary basis.¹⁷ In addition, Part 74 permits certain entities to operate wireless microphones on vacant TV channels on a non-interference basis.¹⁸

15. Further, in 13 metropolitan areas, one to three channels in the range of channels 14-20 are used by licensees in the Private Land Mobile Radio Service under Part 90 of the rules and the Commercial Mobile Radio Service under Part 20 of the rules.¹⁹ In addition, medical telemetry equipment is permitted to operate on an unlicensed basis on any vacant TV channels in the range of channels 7-46, and unlicensed remote control devices are allowed to operate on any TV channels above 70 MHz (*i.e.*, above channel 4), except for channel 37.²⁰ TV channel 37 (608-614 MHz) is allocated for radio

¹³ See 47 C.F.R. §§ 73.610, 622, 623, and 699.

¹⁴ The separations differ depending on the zone where the stations are located and whether the stations are in the VHF or UHF band. See 47 C.F.R. § 73.623(d).

¹⁵ See 47 C.F.R. Part 73 Subpart J. Class A TV stations operate at the power levels permitted for low power television stations under Part 74 of the rules, but have certain protection rights with respect to full service analog and digital TV stations that are not available to TV translator and low power stations.

¹⁶ See 47 C.F.R. Part 74 Subpart G.

¹⁷ See 47 C.F.R. § 74.602(h). This rule section permits TV studio-transmitter links, TV relay stations, and TV translator relay stations to be authorized to operate fixed point-to-point service on UHF TV channels 14-69 on a secondary basis, subject to the provisions in Part 74, subpart G.

¹⁸ See 47 C.F.R. § 74.861.

¹⁹ See 47 C.F.R. Part 90 Subpart L and 47 C.F.R. Part 22 Subpart E.

²⁰ See 47 C.F.R. §§ 15.231, 15.241 and 15.242. Effective October 16, 2002, the Commission ceased granting certifications for new medical telemetry equipment that operates on TV channels, but there is no cutoff on the sale or use of equipment that was certified before that date, *see* 47 C.F.R. § 15.37(i). To provide spectrum for wireless medical telemetry equipment, the Commission established the Wireless Medical Telemetry Service to operate on a primary basis in 13.5 megahertz of spectrum in three spectrum blocks at 608-614 MHz (TV channel 37, which the WMTS now shares with radio astronomy), 1395-1400 MHz, and 1427-1429.5 MHz. See Amendment of Parts 2 and 95 of the Commission's Rules to Create A Wireless Medical Telemetry Service, *Report and Order*, ET Docket No. (continued....)

astronomy and the wireless medical telemetry service (WMTS) and is not used for TV broadcasting. The Offshore Radiotelephone Service uses channels 15-17 in certain regions along the Gulf of Mexico.²¹ In Hawaii, channel 17 is reserved for inter-island communications.²² However, no active licensees currently use this channel in Hawaii, so we will not provide for protection of inter-island communications operations on channel 17 there unless or until an inter-island communications system is activated in that state.

16. On May 13, 2004, the Commission adopted a *Notice of Proposed Rule Making (Notice)* in this proceeding in which it proposed to allow unlicensed operation in the TV bands at locations where frequencies are not in use by licensed services.²³ To ensure that no harmful interference will occur to TV stations and other authorized users of the spectrum, the Commission proposed to define the conditions under which a TV channel is unused and to require unlicensed devices to incorporate "smart radio" features to identify the unused TV channels in the area where they are located. For the purpose of minimizing interference, the Commission proposed to classify unlicensed TVBDs in two general functional categories. The first category would consist of lower power "personal/portable" unlicensed devices, such as Wi-Fi-like cards in laptop computers or wireless in-home local area networks (LANs). The second category would consist of higher power "fixed" unlicensed devices that would operate from a fixed location and could be used to provide commercial services such as wireless broadband Internet access. The Commission proposed to require that fixed devices incorporate a geo-location method such as a Global Positioning System (GPS) receiver or be professionally installed, and that they access a database system to identify vacant channels at their location. It further proposed to require that personal/portable devices operate only when they receive a control signal from a source such as a TV station or FM radio station that identifies the vacant TV channels in that particular area. The Commission also sought comment on the use of spectrum sensing to identify vacant TV channels, but did not propose any specific technical criteria for spectrum sensing.

17. The comments received in response to the *Notice* were divided between the prospective manufacturers and users of unlicensed devices who believe adequate safeguards can be put in place to prevent harmful interference to authorized services, and the existing users of the TV bands who are concerned about potential interference. A number of broadband equipment manufacturers, trade associations and other parties supported allowing unlicensed operation in the TV bands. These parties generally stated that unlicensed devices could operate in the TV bands without causing interference to authorized services. They further stated that allowing such operation in the TV bands could improve access to broadband communications by taking advantage of the favorable propagation characteristics of the TV spectrum and that this would result in more efficient use of this spectrum.²⁴

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99-255, 15 FCC Rcd 11206 (2000). See also, Amendments to Parts 1, 2, 27, and 90 of the Commission's Rules to License Services in the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz, and 2385-2390 MHz Government Transfer Bands, WT Docket No. 02-8, *Memorandum Opinion and Order*, 18 FCC Rcd 16920 (2003).

²¹ See 47 C.F.R. § 2.106 NG66(b) and 47 C.F.R. § 22.1007.

²² See 47 C.F.R. § 22.591.

²³ See *Notice of Proposed Rule Making* in ET Docket Nos. 02-380 and 04-186, 19 FCC Rcd 10018 (2004).

²⁴ See Intel *Notice* comments at 2, Microsoft *Notice* comments at 3, Consumer Electronics Association (CEA) *Notice* reply comments at 3, Motorola *Notice* comments at 1, Telecommunications Industry Association (TIA) *Notice* comments at 4, IEEE 802 *Notice* comments at 4, NAF *Notice* comments at 1, and Wireless Internet Service Provider's Association (WISPA) *Notice* comments at 4.

18. Full service and low power TV broadcasters generally opposed allowing unlicensed operation in the TV bands, expressing concern that unlicensed devices operating under the proposed rules would cause interference to TV reception, particularly in weak signal areas.²⁵ Several parties also expressed concern that unlicensed devices operating in close proximity to TV receivers would cause direct pick-up interference potentially affecting all channels.²⁶ Manufacturers and users of wireless microphones and other broadcast auxiliary services submitted that unlicensed devices would cause harmful interference to those services. Those parties recommended that the Commission take a number of steps to protect auxiliary services.²⁷ Land mobile interests expressed concern about allowing unlicensed operation on channels 14-20 in any part of the country because devices could be transported into areas where those channels are used for PLMRS/CMRS operations.²⁸

19. On October 12, 2006, the Commission adopted the *First R&O/Further Notice* in this proceeding. In that action, the Commission determined that the record received in response to the *Notice* did not contain sufficient information for it to adopt final rules for unlicensed TVBDs. The Commission did, however, make a number of initial decisions regarding TVBDs. It decided to permit fixed unlicensed power devices to operate in the TV bands at times and locations where the spectrum is not already being used by other authorized services. It also decided not to permit operation of unlicensed TVBDs on channel 37, which is used by radio astronomy and wireless medical telemetry services, and on TV channels 52-69, as that spectrum has been reallocated for other services and will no longer be part of the TV bands after the DTV transition. The Commission further decided to prohibit operation of personal/portable TV band devices on TV channels 14-20 to avoid potential conflicts with public safety services on those channels. In addition, the Commission stated that it will not permit marketing of TV band devices to commence until February 18, 2009, the date on which all primary, full service TV stations will be in operation on their permanent DTV channels.

20. In the *First R&O/Further Notice*, the Commission also asked questions and set forth additional proposals with regard to the provisions necessary to implement complete and final rules for unlicensed TV band devices. While the Commission continued to focus on devices operating on an unlicensed basis, it also sought comment on whether such devices should instead operate on a licensed or hybrid basis. The Commission recognized the importance of conducting testing to ensure that whatever standards are ultimately adopted will protect incumbent radio services from interference and indicated

²⁵ See, for example, National Cable and Telecommunications Association (NCTA) *Notice* reply comments at 4, National Association of Broadcasters and Association for Maximum Service Television (NAB/MSTV) *Notice* reply comments at 6, Society of Broadcast Engineers (SBE) *Notice* reply comments at 1, Community Broadcasters Association (CBA) *Notice* reply comments at 3, National Translator Association (NTA) *Notice* comments at 1, Entravision Holdings *Notice* comments at 2, Southwest Colorado TV Translator Association *Notice* comments at 1, Syncom Media Group *Notice* comments at 1, Cox Broadcasting (Cox) *Notice* comments at 8, Pappas Telecasting (Pappas) *Notice* comments at 8, and Region 1 Translator Association *Notice* comments at 2.

²⁶ Direct pick-up interference occurs when undesired signals are received on the internal circuitry of a receiver, rather than at its input terminal as received from an attached antenna. See NAB/MSTV reply comments at 14, CEA comments at 10, and NCTA comments at 5.

²⁷ See, for example, Shure *Notice* comments at 9, Telex Communications *Notice* comments at 2, ATK Audiotek *Notice* comments at 2, Michael Mason *Notice* comments at 2, Total RF Marketing *Notice* comments at 6, Society of Broadcast Engineers *Notice* comments at 2, Sennheiser Electronic Corporation *Notice* comments at 2, National Systems Contractors Association *Notice* comments at 3, and Professional Audio Manufacturers' Alliance *Notice* comments at 3.

²⁸ See Motorola reply comments at 4, Land Mobile Communication Council (LMCC) *Notice* reply comments at 3, Industrial Telecommunications Association (ITA) *Notice* comments at 1, County of Los Angeles *Notice* comments at 2, and Association of Public Safety Communications Officials (APCO) *Notice* comments at 3.

that it intended to conduct extensive testing to assess the potential interference from low power devices operating in the TV bands. It also requested further comment and information on the means that TVBDs, both fixed and personal/portable, should be required to use to determine the availability of unused spectrum. It specifically requested comment on whether it should allow personal/portable devices to rely on spectrum sensing and, if so, the technical features and parameters of the sensing capability to be required. The Commission observed that IEEE 802.22 is considering different sensing threshold detection levels depending on the nature of the source signal, with levels as low as -116 dBm, and invited comment on this value or alternative values for the detection threshold. It also made specific proposals for additional parameters of spectrum sensing capabilities and other technical requirements. The Commission sought comment on whether TV band devices should be permitted to operate on TV channels 2-4, and whether fixed TV band devices should be permitted to operate on TV channels 14-20. The Commission also sought additional comments on several issues relating to the geo-location/database access and control signal approaches discussed in the *Notice*.

21. The comments responding to the *First R&O/Further Notice* are again divided on certain of the major issues in this proceeding. Two groups, one a coalition of hardware and software companies consisting of Dell, Google, HP, Intel, Microsoft and Phillips (the White Space Coalition) and the other a group of public interest/consumer organizations and wireless internet service providers (WISPs), led by the NAF, strongly support low power, unlicensed use of the TV bands. In addition, some other manufacturers and a number of WISPs express support for that approach separately from these groups. Proponents of unlicensed devices believe that the Commission should allow both fixed and personal/portable devices. They also support allowing personal/portable devices to rely solely on spectrum sensing to determine the available channels at their location. The White Space Coalition supports limiting unlicensed operation to channels 21-51 (excluding 37), while the group led by the NAF believes that operation should be permitted on as many channels as possible, including channels 2-4 and channels 14-20 in locations where public safety and land mobile services are not using them.

22. Full service and low power TV broadcasters and cable TV interests generally state that any new services in the TV bands should be licensed to reduce the likelihood of interference to incumbent services. They oppose the introduction of personal/portable devices at this time and believe that any new services should be limited to fixed operation. Broadcasters contend that spectrum sensing alone is inadequate to protect against interference to broadcast operations and that sensing must be combined with geo-location/database access to ensure that low power devices do not operate inside the protected service contours of co-channel or adjacent-channel TV stations.²⁹ Low power TV and translator operators express concern that low power unlicensed devices would cause interference to viewers who rely on reception outside their stations' protected service contours, while cable interests express concern about possible interference to reception of TV signals by cable headends that are located outside TV stations' protected contours. Both broadcast and cable interests express concern about direct pick-up interference to TV receivers, particularly from personal/portable devices.

23. Wireless microphone manufacturers and users again recommend that the Commission adopt a number of requirements to prevent interference to wireless microphones, including: 1) limiting new low power devices to fixed operation, 2) prohibiting new low power devices from operating on

²⁹ The protected service contour for DTV and analog TV stations are contours that define the edge of a station's service area where the availability of service is limited by noise. The DTV and analog protected service contours are generally termed the "noise-limited" and "Grade B" contours, respectively; the definitions of these contours are set forth in Sections 73.622(e) and 73.683 of the rules, respectively. See 47 C.F.R. §§ 73.622(e) and 683. The definitions of the protected service contours of low power DTV and analog stations are specified at signal strength levels that are higher than the noise-limited levels. See Sections 73.6010, 74.707 and 74.792 of the rules; see also 47 C.F.R. §§ 73.6010 and 74.707 and 792.

channels adjacent to occupied TV channels and/or reserving six vacant TV channels in each market for wireless microphones to ensure that spectrum is available for their use, 3) requiring new low power devices to incorporate spectrum sensing to detect wireless microphones, and 4) requiring new low power devices to sense for the presence of a "smart beacon" that would be operated when wireless microphones are in use in an area (Shure has since repudiated its support for a beacon requirement).³⁰ Public safety/land mobile interests believe that new low power devices should not be allowed to operate on channels 14-20 anywhere in the country because of the difficulties in enforcing geographic restrictions on operation.

24. On March 30, 2007, the Commission's Office of Engineering and Technology released a report on the results of its DTV receiver testing program.³¹ This testing program examined the out-of-channel interference rejection performance of a representative sample of eight DTV receivers with fifth generation tuners that were available in 2005 and 2006. A total of 2055 individual measurements were performed on these receivers. Each test involved feeding a desired signal to the television under test and injecting an interfering signal on a different channel or combination of channels. The different tests varied the level of the desired signal and interfering signal(s). In these tests, no receiver appeared to fully achieve the Advanced Television Systems Committee's (ATSC) recommended guidelines for interference rejection performance—guidelines that are generally more stringent than the receiver performance assumptions on which current DTV interference protection criteria are based.³²

25. On July 31, 2007, the Office of Engineering and Technology released a technical report on an initial study of prototype TV band devices that were submitted to the Commission's Laboratory for testing.³³ This report evaluated the performance of two samples of prototype devices; one device had both sensing and transmitting capabilities (although the two functions were not linked) and the other had only sensing capability. This testing found that one of the two devices was generally able to reliably detect TV signals in the laboratory bench tests at the claimed -114 dBm sensing level, but did not perform well sensing wireless microphones. This device was not tested in the field at the manufacturer's request. The other device was not able to reliably sense either TV or wireless microphone signals at the -114 dBm level in either the Laboratory bench tests or in field tests. The builder of this device subsequently determined that the device's sensing function was not operating properly. In an anecdotal observation, the transmitter of the second device was found to cause co-channel and adjacent channel interference to TV service at distances of 87 meters and 47-50 meters, respectively.

³⁰ See Shure *ex parte* comments in ET Docket No. 04-186 submitted May 6, 2008.

³¹ See Office of Engineering and Technology, "Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006," OET Report FCC/OET 07-TR-1003, March 30, 2007 (DTV Receiver Study). Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005).

³² The ATSC provides recommended guidelines for DTV receiver performance in its document, "ATSC Recommended Practice: Receiver Performance Guidelines," ATSC Doc. A/74, 17 June 2004. The DTV Receiver Study found that, after taking into account differences between the Gaussian-noise interferer used for most of the tests and the 8-VSB interferer specified by the ATSC, the best-performing receiver failed to meet the guidelines at only one channel offset, and by only 1 dB. A second receiver failed to meet the voluntary guidelines by 1 to 2 dB at two channel offsets. The remaining five receivers failed to meet the guidelines at two to 16 channel offsets; the worst failure for each of those receivers ranged from about 8 to 24 dB.

³³ See Office of Engineering and Technology "Initial Evaluation of the Performance of Prototype TV-Band White Space Devices," OET Report FCC/OET 07-TR-1006, July 31, 2007 (Initial Measurements Report). Devices were submitted for this initial testing by Microsoft Corporation and Philips Electronics North America Corporation. Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005).

26. Also on July 31, 2007, the Office of Engineering and Technology released a second technical report describing direct pick-up interference tests of three digital cable ready television receivers.³⁴ In these tests, three digital cable ready (DCR) receivers connected directly to cable service were examined for their susceptibility to interference from devices such as might operate within the TV white spaces. Tests were performed with the interfering signal source separated from the DCR receiver by distances of 2 meters or ten meters and, in most observations, by a residential wall. These tests showed that a signal as low as 6.3 dBm EIRP could cause interference at a distance of two meters and that a signal as low as 15.3 dBm could cause interference at a distance of 10 meters.³⁵ While these tests were limited in scope (only three receivers were tested), they nonetheless provide an empirical demonstration of the potential for such interference at relatively low power levels.

27. On October 15, 2008, the Office of Engineering and Technology issued a technical report on a second phase of its study of sample prototype TV band devices.³⁶ This second phase study examined the performance of prototype devices from five parties. All of these devices had capabilities for sensing TV signals, three had capabilities for sensing wireless microphones and one (that of Adaptrum) had a transmit capability (this transmit capability was not linked to the devices sensing capabilities). One of the devices (that of Motorola) also had a geolocation/database access capability.

28. In the laboratory tests of TV signals, the Phase II prototype devices were able to detect a "clean," i.e., unfaded, DTV signal on a single channel at levels in the range of -116 dBm to -126 dBm. The detection threshold sensitivity of the devices varied from -106 dBm to -128 dBm when recorded off-air DTV signals, which included multi-path fading and other "real-world" distortion, were used. When the devices were tested with DTV signals present in adjacent channels, the staff found that in the presence of moderate-to-strong signals in a first adjacent channel, the detection threshold sensitivity of all of the devices was severely impacted. For some of the devices, the degradation in the detection sensitivity was as much as 60-70 dB. In some cases, the degradation was such that the detection threshold could not be measured. The Phase II Measurement Report indicates that this could impact significantly the ability of the devices to reliably detect TV signals within stations' service areas.

³⁴ See Office of Engineering and Technology "Direct-Pickup Interference Tests of Three Consumer Digital Cable Television Receivers Available in 2005," OET Report FCC/OET 07-TR-1005, July 31, 2007 (Direct Pickup Report). Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005).

³⁵ The tests for two meters separation were conducted both with and without an intervening wall between the interferer and the TV receiver. The tests with ten meter separation distances were only conducted with an intervening wall between the interferer and the TV receiver.

³⁶ See Office of Engineering and Technology "Evaluation of the Performance of Prototype TV-Band White Space Devices Phase II," OET Report FCC/OET 08-TR-1005, October 15, 2008 (Phase II Measurement Report). Devices were submitted for the Phase II measurement study by Adaptrum, the Institute for Infocomm Research (I2R), Microsoft Corporation, Motorola, and Philips Electronics North America Corporation. The report is available at <http://www.fcc.gov/oet/projects/tvbanddevice/Welcome.html> under Published Reports. The release of this report was announced by Public Notice. See "The FCC's Office of Engineering and Technology Releases Report on Tests of Prototype TV White Space Devices," Public Notice, DA 08-2243, ET Docket No. 04-186, rel. Oct. 15, 2008. Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005). The peer review was announced by Public Notice. See "The FCC's Office of Engineering and Technology Releases Peer Review Panel Report on Tests of Prototype TV White Space Devices," Public Notice, DA 09-2390, ET Docket No. 04-186, rel. Oct. 28, 2008.

29. TV sensing field tests were performed at nine locations with four of the prototype devices.³⁷ In most cases, the devices correctly reported channels as occupied when the device was operated within the service contour of the stations broadcasting on those channels and viewable signals were observed on the channels. In some instances, however, three of the devices incorrectly reported channels as unoccupied (available) when the device was operated within a station's service contour and the signal was viewable. All of the devices reported some channels as occupied when the WSD was operated outside of the service contours of stations broadcasting on those channels whether the signal was viewable or not. In addition, one device generally reported most channels occupied, whether the device was operating inside or outside any service contours and whether the signal was viewable or not. During the field tests, the Motorola device's geolocation/database access feature was used in combination with its sensing capabilities. In those tests, the Motorola device correctly reported all occupied channels used by stations within whose contours the WSD was operated.

30. The second phase study also examined the ability of devices to sense wireless microphones designed to operate under Part 74 of our rules. The two operating devices with wireless microphone sensing capability, those of Philips and I2R, were tested in the laboratory for their ability to detect wireless microphones (models using both FM/analog and digital) operating within UHF TV channels. With no other signals present, the devices were able to detect wireless microphones at levels ranging from -103 dBm to -129 dBm depending on the type of microphone, and the device. However, in the presence of DTV signals in adjacent channels, the detection threshold of both devices was degraded such that it affected the ability of the devices to reliably detect the microphone signals.

31. Finally, the second phase study conducted tests with the Adaptrum device's transmitter. The device's transmitter was characterized in the laboratory and then used to investigate interference potential to DTV signal reception. Anecdotal tests demonstrated that co-channel interference would occur at line-of-sight distances of up to 360 meters at an EIRP level of approximately +7 dBm when the DTV set was receiving a weak signal off-the-air using a receive antenna at a height of 9.3 meters. No interference was observed when the device transmitted on an immediate adjacent channel even with the transmitter in close proximity to the receiver with a roof-top antenna. No other configurations were tested for interference. Anecdotal tests with the Adaptrum transmitter were performed at two field sites to assess the interference potential from a TVBD transmitter to cable television reception via direct pick-up of signals by cable system components. These tests showed that under certain circumstances, when the transmit antenna was placed in close proximity to a cable connected TV, direct pick-up interference occurred. The report indicated that the direct pick-up interference potential appears to be highly dependent on the interconnection among the various receive system components (e.g., cable amplifiers, splitters and set-top boxes) being used.

IV. DISCUSSION

32. As supported by the record in this proceeding, we conclude that low power devices can and should be allowed to operate in the TV bands on frequencies that are not being used by authorized services. This decision will provide significant benefits for the public by enabling the development and operation of a wide range of new unlicensed wireless communications devices and systems in spectrum where signals are less subject to propagation losses than they are in the bands currently available for such devices. The propagation characteristics of these bands will allow the development of devices that can provide service at greater ranges than existing unlicensed devices. Proponents of broadband devices and services in particular indicate that there is need for new broadband devices that will take advantage of the more desirable propagation characteristics of the TV bands. As indicated above, we believe that the

³⁷ The Microsoft sample devices ceased functioning during the test process and were not repaired or replaced. As a result, only limited tests were conducted on these devices.

propagation advantages of this spectrum will make it possible for WISPs and others to improve or extend their reach to customers in rural and other less densely populated area. We also anticipate that these new devices will have economic benefits for consumers and businesses by facilitating the development of additional competition in the broadband market.

33. It is, of course, most important that we ensure that new unlicensed devices do not interfere with the incumbent licensed services in the TV bands. We now conclude that, with appropriate requirements and conditions on their operation, it is possible for both fixed and personal/portable low power devices to use the TV white spaces without disrupting the important television, public safety, and other services that use these frequencies. Because unlicensed broadband devices will share spectrum with broadcast TV and other licensed services, they will need the capability to avoid causing harmful interference to licensed services in the TV band. Specifically, an unlicensed device will need to be able to determine whether a TV channel or portion of a TV channel is unused before it transmits.³⁸ Additionally, an unlicensed device will need features that enable it to avoid occupying a frequency band or to cease operation on a frequency when a licensed user commences transmission on a channel that was previously unused by a television band licensed service. The rules we are adopting will require that unlicensed TVBDs include these capabilities.

34. The specific provisions of our plan for authorizing unlicensed TVBDs, including our decision to authorize these devices on an unlicensed basis, the requirements for fixed and personal/portable devices, methods and standards for protection of incumbent services, and the technical parameters for operation are described in the following sections; descriptions of the analyses and methods used in defining the operating characteristics of protected signals, the required minimum sensing capabilities, the permissible power levels, and the minimum distances that unlicensed devices must be from a licensed operation are also provided in the text below. The rules for these devices are set forth in Appendix B.

A. Licensed vs. Unlicensed Operation

35. In the *Notice* in this proceeding, the Commission proposed to allow low power devices to operate in the TV bands on an unlicensed basis.³⁹ In their responses, a number of parties suggested that such devices should instead operate on a licensed basis. In the *First R&O/Further Notice*, we sought further comment on whether the proposed TV band devices should operate on an unlicensed, licensed, or hybrid basis.⁴⁰ The record compiled in response to both the *Notice* and *First R&O/Further Notice* includes support for regulating TV band devices as unlicensed, licensed and a hybrid of the two approaches, as discussed below.

36. A number of commenters submit that vacant spectrum in the TV bands should be licensed and that this regimen is necessary in order to enable the use of that spectrum for providing wireless broadband and mobile data services.⁴¹ These parties argue that companies need the assurance

³⁸ We note that the ability to make this determination is unrelated to the determination of whether a household is "served" or "unserved" for purposes of the Satellite Home Viewer Improvement Act. See 17 U.S.C. § 119(a)(2)(B) and (d)(10).

³⁹ See *Notice* at ¶ 14.

⁴⁰ See *First R&O/Further Notice* at ¶¶ 26-32.

⁴¹ See Charles L. Jackson and Dorothy Robyn (Jackson/Robyn) *Further Notice* comments at 26-32; Cox Broadcasting *Further Notice* comments at 6; Qualcomm Inc. *Further Notice* comments at 2; MSTV *Further Notice* reply comments at 31; FiberTower Corp. and the Rural Telecommunications Group, Inc. (RTG) *ex parte* comments at 4-10 (urging that the vacant TV band spectrum be licensed for fixed services to promote broadband deployment in rural areas and to meet the urgent need for wireless backhaul facilities); Sprint Nextel Corp. and T-Mobile USA, Inc. (continued....)

that they will be entitled to protection from harmful interference before they will make the investments necessary to provide these services. They claim that licensing would encourage innovation because a licensee would receive all of the benefits of its innovation instead of having to share those benefits with others. Other parties continue to argue that this spectrum would be more effectively used on an unlicensed basis.⁴² For example, the NAF responds that the existing unlicensed bands have been used for a large number of innovative products, that innovation is encouraged by the low barriers to entry in an unlicensed regime, and that the TV bands have better propagation properties than currently available unlicensed bands, which would cause innovation to flourish.⁴³ It further states that many unlicensed uses such as community networks and rural service do not require a large infrastructure investment, so licensing is not needed to ensure the provision of service. Tropos Networks adds that the expense of acquiring licenses can make providing wireless broadband services prohibitive in rural and Native American tribal areas.⁴⁴ Those supporting the licensed and unlicensed approaches argue a number of additional points and counter points as described below.

37. Jackson/Robyn argue that the TV bands are not well suited to the low-power uses planned by unlicensed advocates.⁴⁵ They contend that under an unlicensed approach, devices would likely have to operate in 6 megahertz channels – which are far smaller than the available bandwidth in the 2.4 GHz or 5.0 GHz unlicensed bands – because the TV band white spaces occur in 6 megahertz increments. Jackson/Robyn further argue that the use of this spectrum for low-power unlicensed devices would fail to take advantage of the better propagation properties of the TV bands compared to those of higher frequencies and to exploit the capability that it is easier to manufacture equipment that generates significant power in the TV bands than at higher frequencies.⁴⁶ The White Space Coalition disputes these views, arguing that Jackson/Robyn's claim that the TV band is not suited to unlicensed uses is premised on the assumption that future unlicensed uses will be identical to the current uses of those unlicensed

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ex parte comments; National Telecommunications Cooperative Association *ex parte* comments; GE Healthcare *ex parte* comments; CTIA *ex parte* comments at 2 (suggesting that the Commission adopt a licensing approach while reserving a portion of the TV band spectrum for future unlicensed use); CTIA and Rural Cellular Association *ex parte* comments at 2-4; Comptel, RTG, Sprint Nextel Corp., FiberTower Corp. *ex parte* comments (suggesting that vacant TV band spectrum be licensed for fixed services using the Commission's Part 101 rules) and the Wireless Internet Service Providers Association *ex parte* presentation July 31, 2008 at 7.

⁴² See White Space Coalition *Further Notice* comments at 21-23; IEEE 802.16 *Further Notice* comments at 5; NAF *Further Notice* comments at 9-58; and Tropos Networks *Further Notice* at 5.

⁴³ See NAF *et al.* *Further Notice* comments at 42. NAF also contends that under the First Amendment the Commission has no right to prevent people from speaking via the use of radio communications by requiring exclusive licensing where the threat of interference does not exist. *Id.* at 53-58.

⁴⁴ See Tropos Networks *Further Notice* comments at 4.

⁴⁵ See Jackson/Robyn *Further Notice* comments at 24-25.

⁴⁶ *Id.* at 24. See also FiberTower Corp. and RTG *ex parte* comments at 16-17; CTIA *ex parte* comments at 15-16. Jackson/Robyn also hypothesize that low-power personal devices such as those the unlicensed advocates envision could be supported under a licensed model. They state that device manufacturers could contract with a licensee to allow consumers who purchase the devices to use them in the white space spectrum. Jackson/Robyn *Further Notice* comments at 6. NAF argues that no manufacturer has expressed an interest in such an arrangement, licensees would avoid such an arrangement because it would be difficult for them to prevent unauthorized use of their spectrum, and consumers would be limited to buying equipment from a single manufacturer (instead of the large number of choices, for example, available with Wi-Fi). NAF *Further Notice* comments at 40.

bands.⁴⁷ It contends that the better propagation properties of the TV bands would make it likely that new unlicensed applications would be developed in the future that would not be possible in other bands.

38. Supporters of a licensed approach also hold that there is no need for additional spectrum for unlicensed devices. In this regard, Qualcomm submits that there is no evidence that consumers have had to return unlicensed devices because the unlicensed spectrum is too crowded.⁴⁸ The Association for Maximum Service Television and the National Association of Broadcasters, in joint comments (MSTV/NAB), add there is over 100 megahertz of unlicensed spectrum below 2 GHz and that 255 MHz of spectrum in the 5 GHz band was made available for unlicensed use in 2003 and so there is plenty of spectrum available for unlicensed use.⁴⁹ The White Space Coalition counters these arguments, stating that the propagation characteristics of the TV band are superior to the other unlicensed bands for many applications and that none of the other unlicensed spectrum is below 900 MHz.⁵⁰

39. Some commenters claim that a large amount of revenue could be generated for the U.S. Government by auctioning licenses for the TV band whitespaces.⁵¹ Based on the value of recent transactions in the 2.5 GHz BRS/EBS band, Jackson/Robyn give an estimate of \$3.7 billion to \$6 billion for the TV white spaces. Commenters supporting an unlicensed approach argue that Jackson/Robyn's estimates of auction proceeds are over-inflated. NAF states that the uncertainty for bidders in this band with respect to the availability of spectrum would be huge.⁵² It observes that there are currently over 5000 low power TV and TV translator stations that have no post-DTV spectrum assignment yet. It further points to the fact that low power auxiliary stations such as wireless microphones have the right to transmit in the whitespaces on any unoccupied TV channel in a possibly wide geographic area. NAF also argues there would be high transaction and coordination costs in using the licensed white spaces because the operating parameters will be different everywhere and that this would further depress the value of the white space spectrum.⁵³

40. Jackson/Robyn claim that licensed use of the TV band would allow up to 50% more of the TV band to be used by TV band devices than unlicensed use would afford.⁵⁴ According to Jackson/Robyn, this efficiency would come from two sources. First, they submit that the use of directional antennas and power control would enable licensees to operate devices up to the edge of a TV station's Grade B/noise-limited contour, whereas unlicensed use of the band would require a buffer zone from 17-46 miles to ensure that unlicensed devices do not interfere with TV receivers within the station's service contour. Secondly, they submit that licensees would be able to negotiate with TV broadcasters to relax the interference requirements in individual situations, and thereby allow greater use of the white spaces. Jackson/Robyn state that if the Commission would allow TV band device licensees to negotiate

⁴⁷ See White Space Coalition *Further Notice* comments at 25.

⁴⁸ See Qualcomm Inc. *Further Notice* comments at 6.

⁴⁹ See MSTV/NAB *Further Notice* comments at 38. FiberTower Corp. and RTG *ex parte* comments at 16.

⁵⁰ See White Space Coalition *Further Notice* comments at 23.

⁵¹ See Jackson/Robyn *Further Notice* comments at 56-57; MSTV/NAB *Further Notice* reply comments at 32-33. FiberTower Corp. and RTG *ex parte* comments at 24-26.

⁵² See NAF *et al.* *Further Notice* comments at 47-50.

⁵³ The National Telecommunications Cooperative Association believes that the unused TV band spectrum should be licensed but not auctioned because the resources of rural carriers are better spent on providing services rather than on buying spectrum. See National Telecommunications Cooperative Association *ex parte* comments.

⁵⁴ See Jackson/Robyn *Further Notice* comments at 15-16.

interference rights with broadcasters, the use of the television bands could evolve over time to more efficient uses as market conditions and technology change dictate.⁵⁵ According to NAF and the White Space Coalition, Jackson/Robyn's claims in this regard are not valid since there is no reason to believe that licensed devices will be able to operate any closer to broadcasters' Grade B contours than unlicensed devices because the same interference protection would have to be provided to broadcasters in either case.⁵⁶ Furthermore, NAF states, allowing broadcasters to negotiate to allow greater interference from white space devices would be contrary to broadcasters' public interest obligations to provide free TV service to viewers because some TV viewers would lose the ability to receive over the air TV service.

41. MSTV/NAB are concerned about possible interference to TV broadcasters from unlicensed devices.⁵⁷ They submit that if unlicensed devices were to cause interference to TV reception, it would be impossible to track down the source of the interference.⁵⁸ They further argue that, as experience with other unlicensed uses has shown, modified devices and nonconforming amplifiers and directional antennas would be sold that would allow unlicensed devices to cause greater interference than allowed under the rules that the Commission adopts.⁵⁹ MSTV/NAB state that a licensed regime would provide accountability for interference in that the licensee would be responsible for any interference that occurs. They submit that the identity of the licensee would be a matter of public record so the party responsible for resolving the interference could be easily located. Jackson/Robyn submit that the infrastructure-based architecture that licensees would be most likely to deploy would reduce the probability of interference compared to low-power unlicensed devices.⁶⁰ On the other hand, the White Space Coalition states that the parameters it has proposed for unlicensed operation would allow unlicensed devices to avoid interference to broadcasters and avoid transmitting at maximum powers.⁶¹

42. A number of parties, including the WISPA, support using a hybrid or "light" licensing model rather than an exclusive licensing model.⁶² They suggest an approach that would be similar to the Commission's rules for non-exclusive licensing of the 3650-3700 MHz band.⁶³ Under their plan, fixed base stations would be registered in a database and registrants would not have exclusive use of the

⁵⁵ *Id.* at 49-50.

⁵⁶ See NAF *et al.* *Further Notice* technical reply comments at 12; the White Space Coalition *Further Notice* comments at 19, 23.

⁵⁷ See MSTV/NAB *Further Notice* comments at 2-5. See also FiberTower Corp. and the RTG *ex parte* comments at 18-21 ("Overcrowding and interference would be much worse in the TV white spaces because of the excellent propagation characteristics."); CTIA *ex parte* comments at 2-3; CTIA and Rural Cellular Association *ex parte* comments at 4-5.

⁵⁸ See MSTV/NAB *Further Notice* reply comments at 31-32 noting that interference is avoided in 2.4 GHz band by the fact that the propagation distances are short so in effect property owners are acting as their own interference coordinators. They state that the propagation properties of the TV band are such that this will not be the case in unlicensed white space operation.

⁵⁹ See MSTV/NAB *Further Notice* comments at 30.

⁶⁰ See Jackson/Robyn *Further Notice* comments at 41.

⁶¹ See White Space Coalition *Further Notice* reply comments at 4-16.

⁶² See Nextwave Broadband Inc. reply comments at 2-3; IEEE 802.16 comments at 5 (IEEE would prefer a completely unlicensed approach but supports a hybrid scheme as an acceptable and viable alternative), WISPA *ex parte* presentation of July 31, 2008 at 7-16.

⁶³ The rules for licensed operation in the 3650-3700 MHz band on a non-exclusive basis are set forth in 47 C.F.R. §§ 90.1301-.1337.

spectrum. These parties suggest that a database system would aid in the resolution of interference problems among the registered users by allowing potential sources of interference to be identified. Supporters of a hybrid approach argue that this plan would present a low barrier to entry, so that innovative low-cost use of the spectrum would still be possible.

43. In their Petition for Reconsideration, NAF/CUWN argues that the Commission should restore its previous tentative conclusion in favor of unlicensed use that was set forth in the *Notice* in this proceeding.⁶⁴ They argue that the Commission provided no explanation for its change of course to give consideration to licensing use of the TV white spaces.

44. *Discussion:* As we stated in the *First R&O/Further Notice*, our goal in this proceeding is to allow new uses of radio on unused television channels at locations where such operations will not result in harmful interference to, or disrupt, TV and other authorized services.⁶⁵ For the reasons discussed below, we conclude that it is in the public interest to allow TV band devices to operate in these bands on an unlicensed basis pursuant to restrictions carefully designed to protect users of incumbent licensed services. This approach permits us to introduce new innovative uses while protecting the continued operation and growth of the TV broadcast and other authorized services in these bands. Because unlicensed operations are not allowed to cause interference to authorized services, the interference protection status of existing services operating in these bands will not be affected, consistent with the Commission's goals in this proceeding.

45. The record developed in response to the *Notice* and *First R&O/Further Notice* indicates that there is a need for additional spectrum for unlicensed broadband devices, particularly in the lower frequency bands. A number of WISPs have noted that the TV frequencies would provide improved signal coverage over other unlicensed bands, including improved in-building penetration properties which other unlicensed bands lack. We disagree with Jackson/Robyn that the 6 megahertz size of TV channels and propagation characteristics of these bands make them inappropriate for unlicensed use. Unlicensed devices will not be limited to 6 megahertz bandwidth, as they will be allowed to operate across multiple channels in locations where the bandwidth is available. The signal coverage afforded by the propagation characteristics of this spectrum is also desired by proponents of unlicensed devices in that it will facilitate the provision of improved and/or more economical wireless Internet service to consumers, particularly in rural areas where transaction costs may be higher than elsewhere. Further, as argued by comments filed by the White Space Coalition and other parties who have expressed interest in developing or operating low power devices in these bands, other innovative uses for this spectrum may emerge once it is made available for unlicensed use.

46. While we recognize the arguments in the record in support of a licensed approach for making the TV white space spectrum available for new uses, we conclude that such an approach is not practicable for many kinds of devices that could use these bands, and thus would reduce the benefits available. As we noted in the *First R&O/Further Notice*, a licensed model tends to work best when spectrum rights are clearly defined, exclusive, flexible and transferable.⁶⁶ When spectrum rights lack these attributes, potential licensees face uncertainty and may lack incentives to invest in a license or offer service. We conclude that attributes supporting the successful use of licensing would be difficult to accomplish here, particularly if we want to maintain our stated goal of not affecting the interference protection status of existing services. The frequencies and amount of unused TV band spectrum will vary from location to location and could change over time as additional television stations and other primary

⁶⁴ See *Notice* at ¶¶ 14-16.

⁶⁵ See *First R&O/Further Notice* at ¶ 1.

⁶⁶ *Id.* at ¶ 27.

and secondary operations are licensed or as existing operations change frequency. For example, the assignment of channels for digital operation to low power television stations is not scheduled to be complete by the end of the DTV transition in February 2009. Also, currently authorized DTV stations have recently been permitted to submit applications asking to modify their facilities and/or change channels.⁶⁷ These changes could complicate licensing of the white spaces spectrum, particularly if the Commission were to license the spectrum pursuant to auction. Because we have decided to require that TV band devices protect other types of licensees in the bands, a licensed TV band device could potentially lose its ability to operate on some, or even all, of its authorized frequencies when new operations with higher allocation status are authorized to operate in the same area.⁶⁸

47. As discussed below, we are adopting a number of requirements for TV band devices that will significantly reduce the potential for these devices to cause harmful interference to authorized services and will make it possible to identify the source of any interference that might occur. In particular, TV band devices will be allowed to operate only after they have identified which channels in their area are available for their use. To ensure that devices adhere to this requirement, we are requiring that fixed and personal/portable TV band devices that do not operate in client mode to access a central database system and that fixed devices register with the database system. Registration of fixed TV band devices will facilitate locating the source of an interference problem should it occur from these higher power devices. We are not requiring registration of personal/portable devices, as the lower operating power and non-directional antennas of personal/portable devices will limit the potential interference range of those devices to the immediate vicinity of a device. We are also concerned that a registration requirement for personal/portable devices could significantly limit the types of devices that could operate by necessitating that a device includes the capability to input alphanumeric data. Thus, this scheme addresses the interference concerns of those commenters who support licensing of TV band devices.

48. With regard to the argument that a licensing regime would encourage investment in the provision of services using wireless spectrum, we observe the stability normally provided by exclusive licensing would be difficult to achieve for TV band device operation. To avoid affecting the interference protection status of incumbent services, the licenses here would afford no right to interference-free operation. Instead, the licensee would merely have the right to operate on those television channels that are not currently in use by other higher-priority users. The specific channels and amount of available spectrum available at a given location could change over time as additional television channels are

⁶⁷ On August 3 2004, the Commission imposed a freeze on the filing of certain requests for changes to TV and DTV channels and service areas. See Public Notice, "Freeze on the Filing of Certain TV and DTV Requests for Allotment or Service Area Changes," 19 FCC Rcd 14810, 14810-11 (2004) ("*August 2004 Filing Freeze PN*"). This freeze was imposed prior to the commencement of the channel election process, in order to provide a stable database for developing the post-transition DTV Table. The freeze precluded parties from filing the following: (i) petitions for rulemaking to change DTV channels within the current DTV Table; (ii) petitions for rulemaking to establish a new DTV channel allotment; (iii) petitions for rulemaking to swap in-core DTV and NTSC channels; (iv) applications to change DTV channel allotments among two or more licensees; (v) petitions for rulemaking by licensees/permittees to change NTSC channels or communities of license; (vi) applications to maximize DTV or analog TV facilities; and (vii) certain Class A television station applications. The freeze did not prevent the processing of pending applications. See *id.*; see also 47 C.F.R. §§ 73.1690, 73.3533, 73.3538. On May 30, 2008, the Commission lifted this freeze. That action effectively allowed stations to file applications for maximization of their facilities and any desired channel changes, immediately and the Commission encouraged stations to file promptly. That action did not, however, lift the current freeze on filing of petitions for allotment of DTV channels for new stations, or for changes in community of license. See Public Notice, "*Commission Lifts the Freeze on the Filing of Maximization Applications and Petitions for Digital Channel Substitutions, Effective Immediately*," DA-1213, released May 30, 2008.

⁶⁸ See *First R&O/Further Notice*, at ¶ 14.

allocated, as low power auxiliary devices make use the channels, and the other services that use these bands similarly initiate new or modify existing operations. Hence, we do not believe that the issuance of licenses would necessarily provide the benefits that the proponents of licensing claim because of the tenuous nature of the rights that would actually be granted by the license. Furthermore, there has been tremendous growth in the development of new technologies and the introduction of new services that rely on unlicensed devices, which belies the assertion that a licensing regime is needed to encourage investment in spectrum development.

49. We are also not persuaded by other arguments raised in support of a licensing regime for TV band devices. We note that a number of parties draw attention to the potential revenue that could be raised by auctioning the unused television bands under a licensing regime. We believe that these arguments are misplaced and do not address our goal in this proceeding, which is to allow new uses on unused television channels in locations where such operations will not result in harmful interference to or disrupt TV and other authorized services. Thus, the regulatory model used here must be appropriate to facilitate new uses while protecting the various types of incumbent uses, not chosen merely because it could provide revenue from auctioning licenses. We are also not persuaded by Jackson/Robyn's claim that licensing TV band devices would allow the television bands to be used more efficiently — *i.e.*, licensed users could negotiate interference protection arrangements and thus increase the use of available spectrum for TV band devices, which in turn would allow the use of the bands to evolve over time to more efficient uses as market conditions and technology change dictate. As discussed above, licensing TV band devices is not practicable while also protecting the present and future use of the band for broadcasting and other incumbent uses. Allowing licensed TV band devices to negotiate interference requirements with licensed users as Jackson/Robyn suggest would signal a fundamental shift from our stated goal to avoid disruption of TV and other authorized services by TV band devices.

50. We also find that a hybrid licensing scheme such as that which the Commission adopted in the 3650 MHz proceeding would not be appropriate here.⁶⁹ In the 3650 MHz band, the Commission decided to issue non-exclusive licenses for stations providing fixed and mobile service. These 3650 MHz stations will be registered in a database which will aid the licensees in resolving interference problems among themselves by allowing them to identify potential sources of interference. However, because that band is allocated to the fixed and mobile services on a primary basis, the registered stations have no interference protection from existing stations of those services in the band. Although the 3650 MHz fixed and mobile stations must protect the previously existing satellite earth stations operating in that band, satellite earth station licenses in the band issued after 2000 are secondary and therefore have no right to interference protection from the new fixed and mobile stations.⁷⁰ The situation in the TV bands is different. Here, future broadcast uses of the television band will have the right to interference protection from TV band devices. Not only must future primary use of the band by broadcasters be protected, but secondary uses such as low power auxiliary devices and broadcast auxiliary service (BAS) must also be protected. Thus, although the non-exclusive licensing approach would address the interference status among TV band devices, it would not resolve the interference rights between TV band devices and other licensed users in the bands. We find that unlicensed operation under Part 15 of our rules is a better fit for TV band devices because Part 15 devices must not cause harmful interference to licensed users, whether primary or secondary. Accordingly, we will authorize new devices on vacant spectrum in the TV bands on an unlicensed basis. Such use will be allowed under the rules discussed in the following sections.

⁶⁹ See *Wireless Operations in the 3650-3700 MHz Band*, ET Docket No. 04-151, *Report & Order*, 20 FCC Rcd 6502 (2005); see also *Rules for Wireless Broadband Services in the 3650-3700 MHz Band*, WT Docket No. 05-96; *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket No. 02-380, *Memorandum Opinion and Order*, 22 FCC Rcd 10421 (2007).

⁷⁰ *Id.* at ¶ 7.

51. With respect to NAF/CUWN's request that we reconsider our decision to reopen the issue of whether use of the TV white spaces should be allowed on a licensed or unlicensed basis, we note that, notwithstanding the petitioners' argument that this issue had been decided, the Commission's position on this issue in the *Notice* was that of a proposal, not a final decision, and it requested comment on that proposal and its tentative conclusions favoring unlicensed use.⁷¹ The Commission decided to request additional comment on this question in the *First R&O/Further Notice* after some parties responding to the *Notice* suggested that this spectrum should be assigned on a licensed basis. Specifically, in the *First Report and Order*, the Commission sought comment on whether the proposed low power operations in the TV bands should be allowed on a licensed, unlicensed, or hybrid basis in the interest of obtaining a further record on this issue. We find nothing arbitrary or otherwise inappropriate in that action. Accordingly, we are denying NAF/CUWN's request that we reverse our decision to seek further comment on the issue of whether to allow low power devices to operate in the TV white spaces on a licensed or unlicensed basis.

B. Plan For Unlicensed Use Of The TV Bands

52. As we observed in the *Notice*, the development of industry standards for broadband unlicensed devices in other frequency bands has enabled the introduction of a host of new unlicensed wireless broadband products that can be divided into two distinct types of operations.⁷² The first type of operation involves the provision of broadband services to homes and businesses. This type of operation uses higher power, is primarily fixed and operated outdoors, may cover a substantial geographic area, and may be part of a service infrastructure. In this regard, Wireless Internet Service Providers (WISPs) are now using unlicensed devices to provide broadband service on a point-to-point basis over distances of several kilometers. The second type involves wireless portable computing devices, such as laptops and personal digital assistants (PDAs), wireless home and local area networks (LANs), and other short-range applications within a home or a business. Unlike the first type of operations, these personal/portable devices generally transmit with very low power and are used indoors or within a small localized area. Portable devices can be used for: broadband wireless connectivity between a cable modem, DSL modem, or other internet connection and in-home computing devices; broadband wireless home entertainment applications, such as video/home theater use; business applications such as wireless inventory control and wireless cash registers; and personal applications such as wireless headphones. Fixed and personal/portable operations may also be used together.

53. For the purpose of developing operating rules and interference protection criteria, we are, as proposed, classifying the unlicensed broadband devices to be used in the TV bands into these two general functional categories. The first category will consist of higher power "fixed" unlicensed devices that are operated from an installed outdoor location that does not change and may be used to provide a commercial service such as wireless broadband Internet access (non-commercial operations will also be permitted). The second category will consist of lower power "personal/portable" unlicensed devices, such as Wi-Fi-like cards in laptop computers or wireless in-home LANs. We find that both of these types of devices can be accommodated in the TV spectrum if they comply with appropriate regulatory measures to ensure that their operations are limited to TV channels where interference will not result. Both types of devices will be allowed to transmit broadband data as well as other types of communications.

54. We recognize that different measures are appropriate for achieving those protections from the two types of devices, given the differences in their uses and interference potential. Therefore, as discussed below, we are adopting different interference avoidance requirements for fixed and personal/portable unlicensed devices. In addition, we are providing for operation of personal/portable

⁷¹ See *Notice* at ¶ 16.

⁷² See *Notice* at ¶ 18.

devices under two different modes: 1) controlled by a fixed device or a Mode II personal/portable device and 2) independent. In each of these cases, our goal is to make the technical requirements as simple and as reliable as possible. We believe that this approach will provide flexibility to permit a wide range of unlicensed broadband uses and applications and while ensuring that the most appropriate and effective mechanisms are in place to protect TV and other licensed services. One of the most important factors in avoiding interference is how to reliably determine the channels that are unused at the location of an unlicensed device. That subject has been a major issue between the incumbent licensed services and the proponents of unlicensed devices. We will first discuss our decision with respect to the methods for determining which channels are occupied at a given location and then address the basic elements of plans for operation of fixed and personal/portable device.

1. Methods For Determining Occupied And Unoccupied Channels

55. With the technologies currently available, there are three principal methods that could be used to determine whether a portion of the TV band is unused at a specific time and/or location. The first approach involves determining the location of an unlicensed device and then accessing a database of licensed services to identify active services at that location. The device's location could be determined by a professional installer or by a geo-location technology, such as GPS, incorporated within the device. Once the device's location is known, an analysis would be performed for each channel using either an internal or external database to determine whether the unlicensed device is located far enough outside the protected service contours of licensed stations to avoid causing harmful interference. This would yield a list of available channels on which the unlicensed device could choose to operate.

56. A second method would be for an unlicensed device to receive information transmitted on a control signal by an external source, such as a broadcast station, CMRS base station, or another unlicensed transmitter, indicating which channels are available at its geographic location. Under the control signal method, a device would be allowed to transmit only after it receives a signal with information that positively identifies which TV channels are available for use. Control signals could be transmitted by any number of sources, such as broadcast TV and radio stations and/or licensed wireless communications providers.

57. A third method would be to incorporate spectrum listening or "sensing" capabilities in the unlicensed device to detect whether other transmitters are operating in an area. For example, a fixed unlicensed transmitter could incorporate an antenna and a receiver capable of detecting signals down to a certain threshold level that would be the standard for determining if a particular TV channel is actually in use. Generally, such sensing would have to be much more sensitive than the receivers used in the licensed service.⁷³ The sensing function would examine each channel and those channels on which it detected no signals above the threshold would be considered available for operation, subject to any additional limitations that might be appropriate. If signals were detected above the threshold on a particular channel, that channel would not be eligible for operation. As the Commission has previously noted, there are techniques that can be used to increase the ability of a sensing receiver to reliably detect

⁷³ Spectrum sensing is also susceptible to a potential shortcoming that is sometimes referred to as the "hidden node problem." In the case of unlicensed devices in the TV band, this problem could arise when there is signal blockage between the unlicensed device and a TV station, but no blockage between the TV station and a TV receiver and no blockage between the unlicensed device and the same TV receiver. In such a case, the sensing receiver in the unlicensed device may not detect the presence of the TV signal because it is blocked, and the unlicensed device may therefore commence transmissions on an occupied channel, thus causing interference at the TV receiver. See *ex parte* presentation by Shared Spectrum Company in ET Docket No. 02-380, on September 29, 2003.

other signals in a band which rely on the fact that it is not necessary to decode the information in a signal to determine whether a signal is present.⁷⁴

58. In the *Notice*, the Commission proposed to require that fixed unlicensed TV band devices incorporate a geo-location method such as a GPS receiver and that they access a database to identify vacant channels at their location.⁷⁵ To ensure that fixed/access devices operate only on unused TV channels, it proposed to require that such devices incorporate a method for determining geographic location with a minimum accuracy of 10 meters. Alternatively, the Commission proposed to allow fixed unlicensed devices to be professionally installed by a party that would determine a device's geographic location and contact the database system to determine the available unused channels at that location. It further proposed to require that personal/portable devices operate only when they receive a control signal from a source such as an FM or TV station or a CMRS provider that identifies the vacant TV channels in that particular area.⁷⁶ The Commission also sought comment on the possibility of using spectrum sensing to identify vacant TV channels, but did not propose any specific technical criteria for that method.⁷⁷

59. In the *First R&O/Further Notice*, the Commission sought additional comment and information on issues related to the appropriate geo-location method, including the means by which devices employing the geo-location/database approach would protect certain authorized services, such as wireless microphones, the location of which may not be included in the databases.⁷⁸ The Commission also recognized that a number of parties suggested that spectrum sensing could be used to identify TV channels that would be available for use by unlicensed TVBDs, but noted that no party had provided sufficient technical information for it to adopt rules. The Commission therefore sought comment on whether unlicensed TV bands devices should be allowed to use spectrum sensing as a means to determine the availability of unused frequencies in the TV bands, and, if so, the technical features and parameters of the sensing capability to be required.⁷⁹ It also requested comment on whether devices should be permitted to rely on spectrum sensing as the sole means of identifying vacant channels, or whether a device should be required to use both geo-location and spectrum sensing to identify vacant channels at its location.⁸⁰ In considering the spectrum sensing approach, the Commission did observe that some parties responding to the *Notice* raised concerns about whether a GPS receiver incorporated in a TV band device would be a reliable method for performing geo-location because it may not work indoors or at outdoor locations where the GPS signal is obstructed.⁸¹

⁷⁴ For example, a TV band spectrum sensing function could be made more sensitive, *i.e.*, made to detect lower signal levels, by using bandwidths much smaller than a 6 MHz TV channel and/or looking for specific features of the TV signal such as the pilot for digital TV or the visual and audio carriers for analog TV. *See Notice of Proposed Rule Making and Order* in ET Docket No. 03-108, 18 FCC Rcd 26859 (2003).

⁷⁵ *See Notice* at ¶ 26.

⁷⁶ *Id.* at ¶ 21.

⁷⁷ *Id.* at ¶ 20.

⁷⁸ *See Further Notice* at 12285.

⁷⁹ *Id.* at ¶ 33.

⁸⁰ *Id.* at ¶ 30.

⁸¹ *See NAB/MSTV Further Notice* comments at 14, IEEE 802 comments at 8, and Society of Broadcast Engineers *Further Notice* comments at 3.

60. A number of the comments received in response to the *First R&O/Further Notice* support the use of a geo-location/database approach for fixed TV band devices.⁸² Those supporting the geo-location/database approach generally state that this method would provide a means to reliably determine occupancy of TV channels by fixed services, but acknowledge that it does not provide for identifying channel occupancy by portable and/or intermittent services such as wireless microphones. MSTV/NAB claim that use of geo-location coupled with a database is the only way to ensure that television stations are protected from interference from TV band devices. Motorola notes that the geo-location/database approach offers flexibility for protection of licensed services as it would allow the restricted radius around TV stations and other protected coverage areas to be changed without changing the TV band devices.⁸³ Motorola believes that the same general techniques that allow fixed devices to operate in the TV bands can also work for personal/portable deployment. It states that an "anchor" personal/portable or fixed device could use geo-location and database techniques to determine its location and send an enabling signal to associated personal/portable devices.⁸⁴

61. In addition, Motorola believes that the database should be flexible enough to vary the applied protection levels depending on the transmit power of the TV band device since the interference potential of TV band devices will vary with transmitted power. It submits that officially established protection levels should be contained in the database to make sure that consistent calculations are performed by various manufacturers' equipment. Motorola also supports the Commission's suggestion that a private party be engaged to develop and maintain such a database.⁸⁵ The Communications Research Centre Canada (CRCC) describes a geo-location method that it states will work indoors, in which a TV band device determines its position by identifying the DTV stations that can be received at its location.⁸⁶

62. IEEE 802, Intel, Josephson Engineering, Motorola, and the NAF all believe that the proposed 10 meter accuracy requirement is more stringent than necessary.⁸⁷ IEEE 802 recommends an accuracy standard of 30 meters as being comparable to that required by the Commission for fixed stations. Intel recommends an accuracy standard of 100 meters, stating that this distance is a small fraction of the required protection distance from TV stations. Motorola similarly recommends an accuracy of 100 meters because TV signal strength varies only a fraction of a dB over this distance. The NAF recommends 100-200 meters on the basis that this range is consistent with the accuracy of station

⁸² The geo-location/database method is supported by the American Society for Healthcare Engineering of the American Hospital association (*Further Notice* comments at 5-6), Communications Research Centre Canada (*Further Notice* comments at 1), IEEE 802.18 comments at 21, Motorola *Further Notice* comments at iii and reply comments at 5-6, MSTV/NAB *Further Notice* reply comments at 16-17, NCTA (*Further Notice* comments at 6), and the WISPA (*Further Notice* reply comments at 3).

⁸³ See Motorola *Notice* reply comments at 6.

⁸⁴ See Motorola *Further Notice* reply comments at 6.

⁸⁵ See Motorola *Notice* comments at 20.

⁸⁶ See Communications Research Centre Canada *Notice* comments at 1.

⁸⁷ See IEEE 802 *Notice* comments at 9, Intel *Notice* comments at 19, Motorola *Notice* reply comments at 8 and NAF *Notice* reply comments at 24.

coverage predictions.⁸⁸ Commenting parties generally believe that the Commission should not require the use of a specific geo-location method such as GPS.⁸⁹

63. The NCTA suggests that rather than requiring Internet access in order for the TV band device to access the database, each television broadcaster could transmit a portion of the database to the TV band device.⁹⁰ Nextwave Broadband supports registration of the location of unlicensed TV band devices in the database as a means to facilitate coordination among the users of these devices and to allow for monitoring of spectrum usage.⁹¹ IEEE 802.18 believes that fixed TV band base stations should be professionally installed, with site surveys, propagation/coverage predictions, and geo-location of the base station.⁹² The White Space Coalition submits that outdoor devices could incorporate a GPS capability in lieu of professional installation.⁹³ Other parties raised questions about who should be considered a professional installer.⁹⁴

64. Several parties express reservations about the use of a geo-location/database approach. The NAF and the White Spaces Coalition are concerned that requiring use of a database will increase costs by increasing the complexity of the TV band devices and requiring payments to a third party to develop and maintain the database.⁹⁵ Tropos Networks argues that no complete and accurate database of broadcast operations currently exists and that the costs of developing one and the associated computational software would be large.⁹⁶ WISPA believes that the wireless Internet service provider market is too dynamic for a registration scheme to ever be current and accurate.⁹⁷ These parties also reiterate their previous concerns that GPS does not function reliably indoors.⁹⁸ For example, the White Space Coalition believes that requiring use of a geo-location/database approach would eliminate the flexibility to create decentralized networks and would restrict indoor use of TV band devices, as unassisted GPS does not function indoors.⁹⁹ Shure, Inc. notes that a database would not protect wireless microphones as these devices are portable and often moved on short notice.¹⁰⁰ Advance Broadband contends that a geo-location/database approach would not be effective because consumers would override

⁸⁸ See IEEE 802 Notice comments at 9, Intel Notice comments at 19, Josephson Engineering Notice comments at 4, Motorola Notice reply comments at 8 and NAF Notice reply comments at 24.

⁸⁹ See Intel Notice comments at 19, Josephson Engineering Notice comments at 3, Motorola Notice reply comments at 8 and NAF Notice reply comments at 24.

⁹⁰ See NCTA Notice reply comments at 13-14.

⁹¹ See Nextwave Broadband Notice comments at 5.

⁹² See IEEE 802.18 Notice comments at 21. This approach requires that each DTV station transmit a unique identification code or "watermark" that can be detected by the TV band device.

⁹³ See White Space Coalition Notice comments at 10.

⁹⁴ See Tropos Notice comments at 4 and Harris Notice comments at 8.

⁹⁵ See Coalition Notice comments at 10; NAF Notice technical comments at 13. The NAF believes that use of geo-location and a database should not be required, but instead should be one option of several possible ways TV band devices could avoid interference. NAF Notice comments at 69.

⁹⁶ See Tropos Networks Notice comments at 12.

⁹⁷ See WISPA Notice comments at 3.

⁹⁸ See Coalition Notice comments at 10 and Thomas C. Smith Notice comments at 10.

⁹⁹ See White Space Coalition Notice comments at 9-11.

¹⁰⁰ See Shure Notice comments at 10.